

CALIFORNIA DIVISION OF MINES AND GEOLOGY

FAULT EVALUATION REPORT FER-108

December 23, 1980

1. Name of fault.

Calaveras and Verona faults (Dublin quadrangle).

2. Location.

Dublin 7.5-minute quadrangle, Alameda ^{and Contra Costa} County (Figure 1).

3. Reason for evaluating.

New information indicates the need to re-evaluate the Special Studies Zones established in 1974. Also, part of 10-year program (Hart, 1980).

4. References.

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Burkland and Associates, February 1972, Preliminary geologic investigation, Tehan Canyon school site, Alameda County, California. Consulting report prepared for Murray School District, Dublin, California, 7 p.

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Dibblee, T.W., Jr., 1980b, Preliminary geologic map of the Niles quadrangle, Alameda County, California: U.S. Geological Survey Open-file Report 80-533C, map (1:24,000 scale).

Dresen, M.D., 1979, Geology & slope stability of part of Pleasanton Ridge, Alameda County, California in Northern California Geological Society Field Trip Guide Book, Spring 1979--Geology and engineering in the Livermore-Hayward region, California, 7 p., 5 figs.

- Ellsworth, W.L., and Marks, S.M., 1980, Seismicity of the Livermore Valley, California, region, 1969-1979: U.S. Geological Survey Open-file Report 80-515, 42 p.
- Ford, R.S., et al., 1970, Livermore and Sunol Valleys, evaluation of ground water resources through 1968: California Department of Water Resources, Memorandum Report (modified by R.S. Ford, 1973, personal communication).
- Gokce, A.O., 1978, Engineering geology and relative stability of Main Ridge and part of Pleasanton Ridge, Alameda County, California: *unpublished* MS thesis, Stanford University.
- Hall, C.A., 1958, Geology and paleontology of the Pleasanton area, Alameda and Contra Costa Counties, California: Univ. of California Publications In Geological Sciences, v. 34, no. 1, 80 p., map.
- Haltenhoff, F.W., 1978, Geology of the Great Valley sequence and related rocks in a portion of the Dublin 7.5-minute quadrangle, California: Unpublished MS thesis, San Jose State University, 78 p., map (1:12,000).
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- Harding, R.C., 1979, Calaveras fault--Dublin area, California in GSA Cordilleran Section Meeting guidebook, Recent Deformation along the Hayward, Calaveras & other fault zones, eastern San Francisco Bay region, CA, p. 52-60: *Geological Soc. Amer., Cordilleran Section, Field Trip Guide*.
- Hart, E.W., 1979, Hayward, Mission, and Calaveras faults, Niles quadrangle: California Division of Mines and Geology Fault Evaluation Report FER-88 (unpublished file report).
- Hart, E.W., 1980, Fault-rupture hazard zones in California: California Division of Mines and Geology Special Publication 42, 25 p.
- Herd, Darrell, 1978, Map of Quaternary faulting along the northern Calaveras fault zone, Las Trampas Ridge, Diablo, Dublin, Niles, and La Costa 7.5' quads, California: U.S. Geol. Survey Open-file Report 78-307, 5 maps (no text), 1:24,000 scale.
- Holden, K.D., 1976, Complete bouguer anomaly map of the Livermore Valley area, California: U.S. Geological Survey Open-file Report 76-761 (map only).
- Lee, W.H.K., 1979, Preliminary map showing earthquake epicenters, 1969 through 1974 in U.S. Geological Survey Open-file Report 79-827.
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Smith, T.C., 1973, unpublished field mapping and air photo interpretation (Dublin quadrangle): California Division of Mines and Geology.

Thronsen, R.E., and Hansen, W.R., 1963, Ground water geology of Alameda County area: California Dept. of Water Resources Bull. 13, Alameda County Investigation, App. C, 151 p.

U.S. Dept. of Agriculture, 1939 and 1940, black and white aerial photographs, vertical, scale 1:20,000 (approx.), BUT-BUU-279-113 to 117, BUT-279-118 to 119, BUT-281-3 to 39, BUT-341-98 to 101.

U.S. Department of Agriculture, 1950, black and white, vertical aerial photographs, scale 1:20,000 (approx.); BUT-BUU-5G-9 to 15; BUT-4G-50 to 52 and 134 to 141, BUT-7G-88 to 91.

U.S. Geological Survey, 1949, aerial photographs, black and white, vertical, 1:24,000, flown 10-13-49, GS-JL 2-26 to 2-29, 2-60 to-62.

U.S. Geological Survey, 1973, Low-sun angle, color, vertical photos, scale approx. 1:20,000, 1-4 to 1-16; flown 9-21-73. (Obtained from Rapidcolor, Burbank, CA.)

5. Review of available data.

Special Studies Zones (SSZ's) were established for the Calaveras, Pleasanton and Verona faults in the Dublin quadrangle in 1974. These

Whitney, J.D., 1865, *Geology of California, Vol. I, Part I, Geology of the Coast Ranges: Geological Survey of California, p. 1-97.*
 Trask, J.B., 1864, *Earthquakes in California from 1800-1864: Proceedings of the California Academy of Sciences, V. 3, p. 130-153.*

zones were based on 11 sources of fault information. Since 1974, fault evaluation studies, both published and unpublished, have revealed the specific location of active fault traces in some places and the absence of active faults elsewhere. This study evaluates the Calaveras and Verona faults and recommends more appropriate zoning. The Pleasanton fault is evaluated in a separate Fault Evaluation Report (FER-109). The northern segment of the Calaveras fault (Diablo quadrangle) will be assessed in FER-110. The adjoining segment to the south (Niles quadrangle) was evaluated by Hart (1979) and rezoned in 1980.

The Calaveras fault is one of the major, active, right-lateral, strike-slip faults in California. It has been mapped as a recently active fault from Hollister to just north of San Ramon, a distance of 115 km. The most northerly point of ^{documented} historic surface activity is near Sunol, a few kilometers south of the study area. At that locality, 1.2 cm of right-lateral displacement was measured at a small triangulation net during a 5-year period (Nason, 1971). A displacement rate of 2-3 mm/year continued through 1975 (NOAA unpublished report). Possible faulting also was reported near San Ramon following the 1861 earthquake (Radbruch, 1968), but the reported fissures may have been due to shaking ~~effects~~.

Various locations have been mapped for the Calaveras fault in the Dublin quadrangle. The more important interpretations prior to 1974 were used to establish the Special Studies Zones and are identified on Figure 2. Traces of the Calaveras fault based on more recent mapping are shown on Figure 3. Observations based on aerial photographic interpretation and field observations of this writer, along with

trench observations (mostly unpublished) of others, are summarized on Figure 4. The work of others is briefly discussed below. Several references are omitted because the mapping is small scale, generalized or not original.

The 1974 SSZ map (Fig. 2) is largely based on Hall (1958) who mapped the area in detail. His location of the Calaveras fault is generalized and apparently inferred largely from stratigraphic truncation. His trace locations appear to be inaccurate. Hall believed that right-lateral separation since late Miocene time was about 3-4 miles. He also mapped the Verona fault south of Pleasanton (Fig. 2). The fault was not verified in the Southern Pacific railroad cut and no recent geomorphic features are visible on aerial photos along the mapped trace that are suggestive of recent faulting of the segment in the Dublin quadrangle. Hall also mapped two western branches of the Calaveras fault near Tehan Canyon, one of which offsets the Livermore Gravels. Another cross-fault is shown to truncate the two branch faults. Except for a soil-filled fissure (Figures 3 and 4), there is little or no evidence for Holocene fault offset on any of these subsidiary faults (also see locality 1, Table 2).

Ford's, (1970) traces of the Calaveras fault are somewhat similar to Hall's, but differ in detail. His work was directed at determining groundwater units in the Livermore basin and, ^{a short segment in the southern part of the Dublin quadrangle,} except for ¹ was not used for zoning of the Calaveras fault. Earlier reports of the Department of Water Resources show the fault similarly (e.g. Thronsen and Hansen, 1963). ↑

Brown interpreted 1:80,000-scale aerial photos and identified the trace (generalized) of the Calaveras fault from San Ramon to Pleasanton.

Ford also showed 3 traces for the Verona fault (Fig. 3), the middle trace corresponding to Hall's. These faults offset Livermore Gravels and Miocene beds, but are concealed by recent alluvium. Only the northern trace is reported to be a significant groundwater barrier, but it is not shown to extend to the surface (Ford, p. 133-134, section H-H'). [No evidence of recent surface faulting was noted on aerial photos or in trench excavations.]

The scale of the mapping was considered too small to use for zoning in view of the more detailed work available. His trace is similar in location to that of Levish (1973) and Burkland and Assoc. (1972) (Fig. 2).

The other traces of the Calaveras fault shown on Figure 2 are from unpublished mapping of Smith (1973), Levish (1973) and Burkland and Associates (1972). Smith's work was mainly aerial photo interpretation ^(1:80,000 scale photos) and reconnaissance field mapping for the purpose of establishing Special Studies Zones. Levish's and Burkland's work was based on aerial photo interpretation, field reconnaissance, trenching, and geophysical interpretations used to evaluate individual sites for development. Harding (1979), based on site investigations, confirmed the location of the Calaveras fault in the vicinity of Dublin to be similar to Levish (1973).

Several geologists have mapped all or parts of the Calaveras fault in the Dublin quadrangle since 1974. Earliest of these is Perkins (1974) who shows two traces south of Highway I-580. The eastern trace is similar to Hall (1974) and the western trace similar to Dibblee (1980) (see Fig. 3). Perkins shows the faults to be mostly concealed and provides no specific documentation for locating the faults where he does.

Herd (1978) mapped the traces of Quaternary faults in the Dublin quadrangle, using aerial photos and field checking. He does not indicate which traces are the youngest or most active. As can be seen on Figure 3, his traces are discontinuous and branching. The solid line apparently represents well-defined and linear scarps, drainages and tonal features. The dotted lines represent

concealed faults and mostly are based on less well-defined scarps. The line of traces from Dublin to the vicinity^{of} Tehan Canyon rather closely follow the main active trace of this study (Figure 4). However, some of Herd's traces north of Dublin have been trenched and no Holocene-active fault identified (Figure 3). The arcuate trace just north of Alviso Adobe also has been trenched in four places, but only one trench exposed what was believed to be a recently active fault. Two of the trenches excavated across the northern part of the scarp^{in December 1980} failed to find evidence of faulting (see Figures 3 and 4 for trench location and Item 6 below and Table 2 for additional discussion). The other traces of Herd have not been verified as fault related. He does not map any faults through the massive landslide deposits in the southern part of the quadrangle.

Gokce (1978, p. 31-35, Pl. 1) mapped "a single active trace of the Calaveras fault" from Bernal Avenue northward to Tehan Canyon on the basis of tonal and vegetation contrasts, a low scarp, furrow, and sag pond. His trace location partly coincides with that of Herd (1978) and was trenched (see above). However, his tonal lineament south of Alviso Adobe is slight mislocated to the east. This tonal was trenched and no fault observed (Figure 4). Moreover, the one-foot high scarp report^{ed} along a fence line by Gokce was observed 12/11/80 and almost certainly is due to cultivation northeast of the fence. The fault features reported northwest of the scarp could not be verified in this study or by others (e.g. Herd, 1978). Gokce also mapped a main trace and two western branches just north of Tehan Canyon (not shown on Fig. 3), which are similar to the traces of Haltenhoff (1978). He did not consider the branch faults to be active.

Haltenhoff (1978) mapped a 5-km segment of the Calaveras fault in the vicinity of Tehan Canyon (Figure 3). Most of his fault traces are shown as concealed, approximately located, and inferred. His fault locations are partly based on the work of others. South of Tehan Canyon there is a single fault that is inferred to exist at the break in slope of Pleasanton Ridge and is marked by an extensive zone of landsliding. It generally follows the trace of Perkins (1974), Dibblee (1980) and this study. North of Tehan Canyon, the fault is shown to trend more northwesterly and to split into two branches that separate unlike rock units. These traces are reportedly based on the work of Burkland and Associates (1973, and a 1972 report that was superceded by the 1973 report), who used aerial photo, field work, ^{to interpret these faults.} and magnetic anomalies. Haltenhoff did report a 40 cm-wide soil-filled fissure in a road cut along the eastern trace, which was verified in this study. [However, I was unable to verify the existence of any recent geomorphic features that would suggest significant recent dip-slip or strike-slip offset for either trace (see item 6 below).] Moreover, the eastern trace is shown by Haltenhoff to be concealed by Livermore Gravels north of the road cut. Haltenhoff presents no other specific evidence to suggest that either of these northwestern faults are recently active or even are of Holocene age. Some of Haltenhoff's data are also published in Haltenhoff (1979).

Dresen (1979), based on his 1979 MS thesis (Hayward State Univ.), located the Calaveras fault a kilometer west of Foothill Road in the southern part of the Dublin quadrangle and in the adjacent Niles quadrangle. The trace was located on ^{the} basis of the linear, northwest-trending escarpment of Pleasanton Ridge and the contact between

contrasting units. He considered the fault to be the "fundamental boundary between the Great Valley Sequence to the west and the Cenozoic strata to the east". Most of the trace in the Dublin quadrangle is shown to be concealed within a large landslide deposit. Massive and extensive landslides have also been mapped along the northeastern side of Pleasanton Ridge south of Alviso Adobe by Nilsen (1973), Herd (1978) Gokce (1978), Haltenhoff (1979), and this writer (Hart, 1979; this study). The boundaries of the principal landslides of Herd (1978) and this study are shown on Figure 3 and 4, respectively.

Dibblee (1980a) shows the position of the Calaveras fault as indicated on Figure 3. His trace generally defines the major discontinuity between Cretaceous and Miocene strata on the west and upper Cenozoic beds on the east. Where the trace is in Holocene alluvium, it is shown as concealed. His trace does not coincide in most places with the known or inferred active trace of this study. However, Dibblee's work does provide general support for the existence and general location of a major, through-going geologic fault.

In the Niles quadrangle to the south, Herd (1978), Hart (1979), and Dibblee (1980b), map the active trace of the Calaveras fault within 1-2 km of the Dublin quadrangle boundary. That trace is similar to Perkins (1974) and is on trend with the traces of this study, Dresen (1979) and Dibblee (1980b).

Holden (1976) made a gravity anomaly map which shows a steep gravity gradient that generally coincides with the Calaveras fault from Sunol Valley northwest to Dublin. The data suggest that the main trace of the fault lies along the northeast^{ern} flank of Pleasanton Ridge.

Table 1 (FER-108). Unpublished Fault-investigation reports providing observational data on the Calaveras fault, Dublin quadrangle. All reports are on file in the San Francisco office of CDMG, Rm. 1016. Trench locations are plotted on Figure 4. File numbers refer to reports filed under the Alquist-Priolo Act (AP) or informally filed consulting reports (C-).

CDMG file #	Investigation firm	Site description and locality	Date of report	Was trenching done?	Comments
AP 37	Judd Hull/R. Burton Rose	Country Lane, Pleasanton	Nov. 1974	Yes	No faults found.
AP 65	Burkland & Assoc.	Dublin Green, San Ramon	Mar. 1975	Yes	Fault exposed in trenches.
AP 101	Judd Hull & Assoc.	Country Lane, Pleasanton	Nov. 1974	Yes	No faults found
AP 177	Judd Hull & Assoc.	Castlewood Country Club, Pleasanton	May 1975	Yes	N40°E-dipping fault interpreted in landslide deposits; soil not offset.
AP 178	Judd Hull & Assoc.	Country Lane, Pleasanton	Jan. 1976	Yes	No faults found.
AP 226	Terrasearch, Inc.	Shopping Center, San Ramon	Feb/Apr. 1976	Yes	No faults found.
AP 231	Terrasearch, Inc.	Dublin Blvd., Dublin	May 1976	Yes	No faults found.
AP 278	Harding-Lawson Assoc.	Catholic Church, Dublin	Sept/Oct. 1975	Yes	Faults found in bedrock; not active.
AP 444	Engeo, Inc.	Harlan Ranch, San Ramon	Aug. 1976 Jan/Jul. 1977	Yes	Fault found to offset soil
AP 514	Terrasearch, Inc.	Parcel 4010, San Ramon Village	Mar/Aug. 1976	Yes	No faults found.
AP 536	Kaldveer & Assoc.	San Ramon Village	Aug. 1977	Yes	No faults found.

Appendix I to FER-108 (cont.)

CDMG file #	Investigation firm	Site description and locality	Date of report	Was trenching done?	Comments
AP 690	Terrasearch, Inc.	Tract 4372, Pleasanton	Oct. 1977 Mar. 1980	Yes	Fault found, soil offset.
AP 785	Judd Hull & Assoc.	Castlewood Dr., Pleasanton	Apr. 1977	Yes	No faults found; landslides.
AP 953	Terrasearch, Inc.	Little Kids Center, Dublin	Jan. 1979	Yes	No faults found.
AP 989	Earth Systems Consultants	The Springs, Dublin	May 1979	Yes	Soil, alluvium, gw table offset by fault.
AP 991	HMS Associates	San Ramon Rd., Dublin	Apr. 1979	Yes	No faults found.
AP 994	Earth Systems Consultants	"Parcel 400", Pleasanton	June 1979	Yes	Offset soil, alluvium and ground water barrier identified by trenching and boreholes. Based largely on Burkland & Assoc. report of 1972.
AP 1002	Terrasearch, Inc.	Tract 4077, N. of Dublin	Jun. 1978, Aug. 1979	Yes	No faults found.
AP 1021	Judd Hull & Assoc.	Happy Valley Rd., Pleasanton	Jun. 1979	No	No fault observed in steeply dipping beds of Livermore & Briones formations; RA cut.
AP 1053	Terrasearch	San Ramon Rd., Dublin	Feb. 1979	Yes	No faults found.
AP 1062	Earth Systems Consultants	Tract 4236, Dublin	Jun/Dec. 1979	Yes	No faults found.

Appendix I to FER-108 (cont.)

CDMG file #	Investigation firm	Site description and locality	Date of report	Was trenching done?	Comments
AP 1125	Burkland & Assoc. and Earth Systems Consultants	Dublin Rd., Dublin	Jan. 1973, Dec. 1978	Yes	Soil, alluvium, groundwater table offset by fault.
AP 1126	Earth Systems Consultants	Festival Plaza, Dublin	Oct. 1979	Yes	Fault found, same as AP 1125.
AP 1127	Soil Foundation Systems	W. of San Ramon Village	Feb. 1980	Yes	Faults not identified in trenches.
AP 1218	Earth Systems Consultants	Tract 4372, Pleasanton	Aug. 1980	Yes	No evidence of Verona fault of Hall (1958) in trenches or road cut.
AP 1220	Earth Systems Consultants	United Presbyterian Church, Dublin	Aug. 1979	Yes	No faults found.
AP 1233	Terrasearch, Inc.	Foothill Rd., Pleasanton	Oct. 1980	Yes	No fault found in alluvium.
AP 1246 - see C-454					
C-17	Burkland & Assoc.	Tehan Canyon School site, Pleasanton	Jul. 1973	Yes	Young soil offset by fault.
C-39	Gribaldo, Jones & Assoc.	Laguna Vista Estates,	Feb. 1970	Yes	No fault found in trench.
C-415	Gribaldo, Jones & Assoc.	Foothill Rd. school,	Jan. 1970	Yes	No fault found in alluvium.
C-451	Burkland & Assoc.	Foothill reservoir site, Pleasanton	Jul. 1973	Yes	Fault found between conglomerate (QTzg?) on sand alluv. on E; N10°W strike, 80°E dip. Shallow dozer trenches.

Appendix I to FER-108 (cont.)

CDMG file #	Investigation firm	Site description and locality	Date of report	Was trench- ing done?	Comments
C-452	Burkland & Assoc.	Lands of Castlewood, Pleasanton	May 1973	Yes	"Shear" reported at 10' depth in alluv., but overlying beds not faulted.
C-454 (now AP 1246)	Earth Systems	Stoneridge, Pleasanton	Jun. 1970	Yes	No faults found.
C-455 472	Gribaldo, Jones & Assoc.	Meadowlark Dairy, Pleasanton	Sept. 1969 Jul. 1970	Yes	5' wide, vertical zone of wet. soil exposed; overlying soil offset 16" at base of scarp. Trenches across scarp to N and tonal lineament to S did not expose fault in alluvium. No trench logs in report.
C-373	Terrasearch, Inc.		Jun 1976	Yes	Faulted alluvium; ground- water barrier in 2 trenches.

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Numerous consulting reports on file with CDMG have been prepared by others for sites along the Calaveras^{and Verona} faults. Those reports providing fault data^{from} trench excavations and other artificial cuts are summarized in Table 1. Locations of trenches are shown on Figure 2.

6. Interpretation of aerial photographs; field observations.

Several days were spent carefully interpreting aerial photographs (USDA, 1939, 1940 and 1950; USGS, 1949 and 1973) to identify those features indicative of recent faulting along the Calaveras fault zone. This was followed by limited field checking south of Dublin and by comparison with trench excavation logs (mainly unpublished) to verify the existence and recency of faulting. These data are summarized in Figure 4.

The principal recent trace is more or less continuous, although it locally varies in trend and appears to step left in several places. Several short linear features also were observed nearby, and some of these may be active faults. (Some also may be inactive faults or not fault related.)

The best-defined segment is 4-5 km long and centers on Dublin and Tehan Canyon. It is marked by a narrow zone of steep linear scarps, right-laterally offset drainages, and groundwater barriers (tonal lineaments) in Holocene alluvium. This fault segment is well-documented by trenching (Table 1 and Fig. 2) and most workers agree as to its location.

North of Dublin, the main trace is partly masked by landslides and somewhat difficult to identify. However, a 1-km long segment, extending northward from the mouth of Big Canyon, is marked by well-defined linear features (Fig. 4). The subtle features in the northernmost

part of the quadrangle coincide with faulted soils exposed in two trenches (Figure 4 and Table 1). The four linear traces west of the main trace, at the mouths of Koopman and Clark Canyons, are probably fault-related. The best-defined trace west of the water tank has been mapped by most investigators--either as the main Calaveras fault or a recently active ^{branch}_{fault}. Trenching, however, ^{along this trace} has failed to reveal any recent faults (see AP 514 & AP 1127, Fig. 2 and Table 1; also Harding, 1979). The other traces have not been trenched.

South of Tehan Canyon, the active trace of the Calaveras fault is extensively obscured by landsliding. The specific location of the active trace is fairly well indicated by linear features over a length of 2 km centering on Locality 3 (see Table 2 and Fig. 4). South of there, the general location of the trace is suggested by a general alignment of headwall scarps of the massive landslide deposits that extend 5-6 km southward. This scarp aligns with the known trace of the ^{active} fault on the Niles quadrangle (Figure 4). Subtle geomorphic and tonal features within the landslide suggest the specific location of the active fault trace. The linear features mapped to the east and interpreted by others (e.g. Herd, 1978; Gokce, 1978) are either not fault-related or not due to Holocene faulting (see localities 2, 4 and 5, Fig. 4 and Table 2).

There is no substantial evidence for the existence of Verona fault of Hall (1958) in the southwest corner of the quadrangle. The contact between the Livermore Gravels (Plio-Pleistocene) and underlying Briones Formation (late Miocene) lies south of where Hall maps it.

Table 2. Observations of features along the Calaveras fault south of Highway 1-580 (see Figure 4 for localities).

1. Soil-filled fissure along near-vertical ^{fault} between sheared serpentine on the west and steeply-dipping Livermore Gravels (Plio-Pleistocene) on the east is exposed in road cut. This is described in some detail by Haltenhoff (1978, 1979), who indicates this to be the main trace of the fault. The fissure is about 30-60 cm wide narrowing with depth. The soil-filling is well-compacted and may represent an older (e.g. pre-Holocene) soil. The overlying soil/colluvium unit thickens over the fissure, but does not appear to be offset. Aerial photos and ground observation reveal a NE-facing scarp which is probably erosional. There is no evidence of recent features normally associated with recent faulting and the fault cannot be traced to the north. The soil-filled fissure presumably is due to minimal extensional opening, probably as a result of minor downhill movement, during late Quaternary time. The main active trace to the east is clearly defined along Foothill Road (Figure 4).
2. Well-defined, arcuate, east-facing scarp, considered by Herd (1978) and Gokce (1978) to be fault-related. Scarp does not appear to offset Holocene fan deposits that cross it and cannot be directly associated with other features to the north or south. The scarp has a constant slope to the east, sub-parallel to the underlying beds of the Livermore Gravels. Although the toe of the scarp is moderately well-defined, there is no evidence of recent uplift. Faulted alluvium was ^{in one trench} reported by Gribaldo, Jones & Assoc. in 1970 (see unpublished report C-455 in Table 1 and Fig. 4), but a second trench did not verify this (no trench logs available). Trenching to the south along a tonal lineament (reports C-452 and C-455) did not verify the reported fault. Two recently excavated trenches to the north did not expose a fault at the scarp, and the recent alluvial deposits were depositional on the Livermore Gravels. According to M. Levish (p.c. 1980), a stream-channel deposit was exposed at the base of the scarp in the northern trench, and probably formed by side-cutting of the Tehan Canyon drainage when it formerly flowed between the shutter ridge and the main ridge to the west. The main active fault is mapped to the west of Foothill Road (Figure 4). The one-foot high scarp reported by Gokce (1978) ^{lies} along a fence line and is clearly the result of repeated plowing in the lower field east of the scarp.
3. Location of active fault strongly suggested by the sidehill bench, linear trough, and deflected drainages to the north and a zone of closely spaced right-laterally deflected drainages to the south; partly masked by landslides.
4. A NNW-trending lineament near Castlewood Country Club is reported by Judd Hull and Assoc. (1975 unpublished report A-P 177 in Table 1; also see Fig. 2 and 4). They reported a 40° NE-dipping fault in landslide deposits. Their trench log does not indicate offset of the overlying soil and the interpreted structures could be due to landsliding. Although the hill slope west of Foothill Road is now benched, the

linearity of these features does not show on early aerial photos (USDA, 1940 & 1950). The photos show hummocky topography (landslide deposits) and a road near the inferred lineament. The site additionally has been modified by grading for a "pitch and putt" golf course (post-1950), which enhanced the benching. Cracks in Foothill Road (east) and Oak Lane (south) indicate recent downhill movement, probably related to landsliding. There is no evidence of a fault in the alluvial re-entrant valley 500 meters to the south--neither on the aerial photos nor reported in site-investigation at that locality (see Fig. 2 and Table 1, reports AP 37, 101, 178).

5. Broad linear trough separating hummocky landslide deposits on the west from a relatively coherent rock mass on east. The trough lies within a large, complex landslide with the headwall scarp lying high on Pleasanton Ridge and the toe encroaching on Arroyo de la Laguna. Closed depressions, extensive benches, and the steepness of the headwall scarp indicate continued Holocene movement of this late Quaternary feature. The broad trough may represent the dislocated former trace of the Calaveras fault.
6. Discontinuous exposures of Livermore Gravels in railroad cut. Non-marine gravel beds of the Livermore Gravels dip 30-60° NE north of the bridge and near vertically south of the bridge. The sequence of beds appears to be more or less conformable with the underlying Briones sandstone and mudstone (upper Miocene, marine?). Minor faulting (undetermined age), but sequence more or less intact. No fault mapped by Dibblee (1980a) here.
7. Three trenches 6-9' deep and 100-150' long each, dug by Judd-Hull & Associates 12/30/80. Observed 12/31/80, when partly unshored and walls incompletely cleaned (see Fig. 2 for approximate location). Northern two trenches exposed poorly stratified to massive colluvial soil and landslide debris with Cretaceous bedrock at west end of western trench. No faults seen, but clay seams indicate late Quaternary downhill movement and debris may conceal fault. Also, east end of western trench is in clayey, massive colluvium with minor vertical cracks. Trench to south is on bench at mouth of gully and exposed debris fan material on uneven surface of weathered Cretaceous bedrock. No faults seen, but hummocky and benched terrain S and W suggest massive, deep (?), recent landsliding. The fault trace of Dibblee (1980a) lies just to the west of the trench sites.

The sequence is more or less intact, but is deformed and is cut by minor faults. There is no evidence of recent fault scarps, offset drainages, or other features indicative of recent faulting (Fig. 4, Tables 1 and 2). The Verona fault is not mapped by Dibblee (1980a).

Some of the controversial features observed south of Highway 1-580 are discussed in additional detail in Table 2.

7. Seismicity.

Earthquake epicenters that have been specially studied and that are accurately located (generally within 2-3 km) are classified as "A" quality data and plotted by Real and others (1978). The relationship of these epicenters to the principal faults in the vicinity of the Dublin quadrangle are shown on Figure 3. Lee (1979) provides a similar epicenter map. The Calaveras fault is well-defined by seismicity south of the Calaveras Reservoir; between there and Sunol, it is moderately well-defined. The fault is not well-defined by seismicity within the Dublin quadrangle and to the north. Ellsworth and Marks (1980) draw a similar conclusion.

The most northerly evidence of fault creep south of Sunol is consistent with the seismicity. If this relationship is valid, then fault creep would not be expected for the Calaveras fault in the Dublin quadrangle (*none has been found to date*).

8. Conclusions.

Based on this study and the mapping of others (e.g. Hall, 1958; Dibblee, 1980a and 1980b; Dresen, 1978), it is concluded that the Calaveras fault in the Dublin quadrangle is a major right-lateral,

strike-slip fault that has been active in recent geologic time. It constitutes a major discontinuity between Cretaceous and Tertiary beds on the west and late Cenozoic beds on the east.

The location of the main, active-fault trace is defined by youthful geomorphic features (linear scarps and troughs, right-laterally deflected drainages, sag ponds, sidehill benches, etc.) and ^{local} groundwater barriers. These features, partly developed in recent alluvium, are similar to the features associated with other Holocene and historically active strike-slip faults. Additionally, trench excavations reveal that young alluvium and soil of probable Holocene age have been faulted (Figures 2 and 4, table 1). The traces of recently active faults have been located with considerable precision northward from Alviso Adobe (Figure 4). South of there, the traces are largely obscured by massive landslides, but the general position is indicated by the alignment of headwall scarps of the landslides and the truncation of geologic units (Dibblee, 1980; Hall, 1958; Drasen, 1979). There is no evidence that the main trace lies to the east as inferred by others (e.g. Hall, 1958; Ford, 1970).

The linear traces mapped west of the main trace north of Dublin may represent active faults (Figure 4), but this has not been verified by trenching. The trace in Laurel Creek (south of Dublin) is believed to be erosional. The western branch faults near Tehan Canyon (Burkland and Associates, 1973; Haltenhoff, 1978; Hall, 1958) are not considered to be active, through-going faults, although they may represent older faults (see Locality 1, Fig. 4 and Table 2).

The features mapped east of the main trace and south of Alviso Adobe are partly the result of slumping and partly artificial. The scarp north ^{and east} of Alviso Adobe does not appear to be due to Holocene

faulting, although it may be a Quaternary fault in part. The fault reported in one trench could not be verified in three other trenches that cross the scarp (Locality 2 of Figure 4 & Table 2). It is concluded that the scarp is largely erosional and not the result of Holocene faulting (although it may be partly coincidental with a pre-Holocene (?) fault).

The active fault traces mapped for this study partly coincide with the traces of other workers (e.g. Harding, 1979; Smith, 1973; Burkland and Assoc., 1973; Herd, 1978). However, the traces of others are, for the most part, mislocated 30 m or more.

There is no evidence that the Verona fault of Hall (1958) is active, or even represents a significant fault.

9. Recommendations.

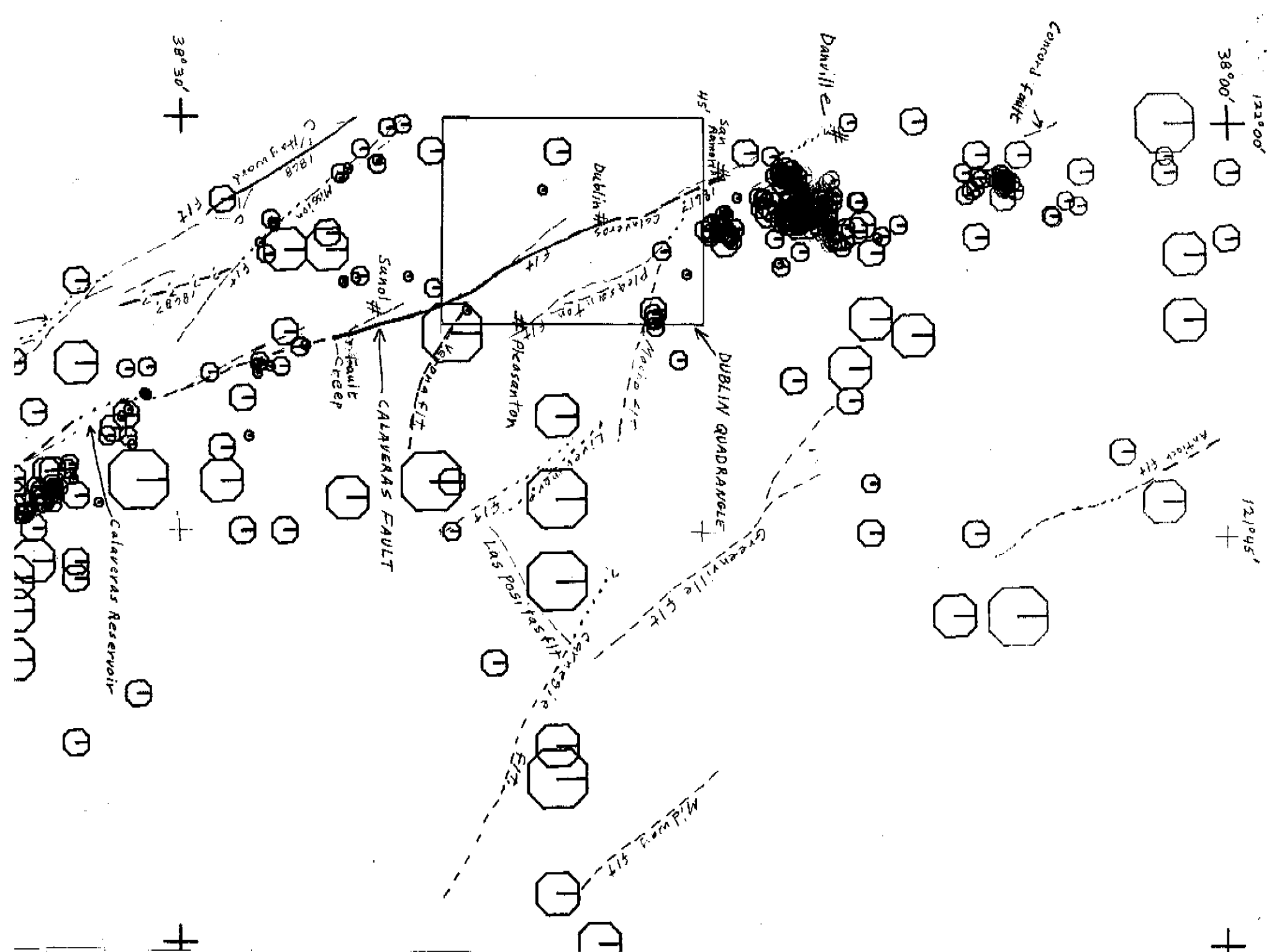
It is recommended that the existing Special Studies Zone (SSZ) delineated for the Calaveras fault be revised based on this study. Specifically, the zone map should show 1) the main trace and 2) the branch faults west of the main trace north of Dublin. The faults recommended for revised zoning meet the criteria of "sufficiently active and well-defined" (Hart, 1980).

The zone encompassing the Verona fault of Hall should be deleted. The location of the proposed revised SSZ boundary is shown in pencil on Figure 4.

10. Report prepared by:

Earl W. Hart

Earl W. Hart
December 23, 1980



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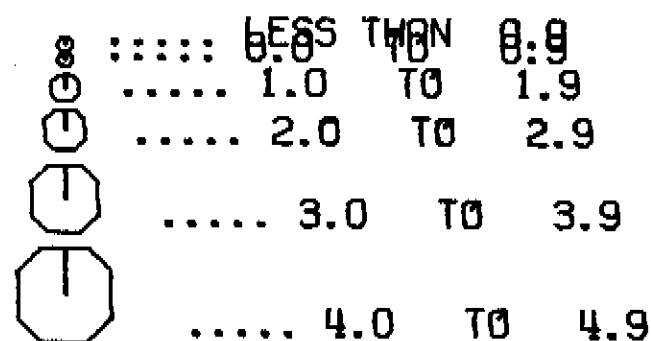
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MAGNITUDE



★ NO MAGNITUDE OR INTENSITY ASSIGNED

Figure 5. Locations of "A" quality earthquake epicenters in vicinity of Dublin quadrangle (after Real, et al, 1978) and principal faults.